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# UTILITY PATENT APPLICATION TRANSMITTAL

Attorney Docket No. MI22-1098

Total Pages

First Named Inventor or Application Identifier

Klaus F. Schuegraf

(Only for new nonprovisional applications under 37 CFR 1.53(b))

Express Mail Label No. EL169836626US

APPLICATION ELEMENTS  
See MPEP chapter 600 concerning utility patent application contents.

ADDRESS TO: Assistant Commissioner for Patents  
Box Patent Application  
Washington, DC 20231

1. ☒ Fee Transmittal Form  
(Submit an original, and a duplicate for fee processing)
2. ☒ Specification [Total Pages 26]  
(preferred arrangement set forth below)
  - Descriptive title of the Invention + cover sheet
  - Cross References to Related Applications
  - Statement Regarding Fed sponsored R & D
  - Reference to Microfiche Appendix
  - Background of the Invention
  - Brief Summary of the Invention
  - Brief Description of the Drawings (if filed)
  - Detailed Description
  - Claim(s)
  - Abstract of the Disclosure
3. ☒ Drawing(s) (35 USC 113) [Total Sheets 2]
4. Oath or Declaration [Total Pages 3]
  - a. ☐ Newly executed (original or copy)
  - b. ☒ Copy from a prior application (37 CFR 1.63(d))  
(for continuation/divisional with Box 17 completed)  
[Note Box 5 below]
    - i. ☐ DELETION OF INVENTOR(S)  
Signed statement attached deleting inventor(s) named in the prior application, see 37 CFR 1.63(d)(2) and 1.33(b).
5. ☒ Incorporation By Reference (useable if Box 4b is checked)  
The entire disclosure of the prior application, from which a copy of the oath or declaration is supplied under Box 4b, is considered as being part of the disclosure of the accompanying application and is hereby incorporated by reference therein.

6. ☐ Microfiche Computer Program (Appendix)
7. Nucleotide and/or Amino Acid Sequence Submission (if applicable, all necessary)
  - a. ☐ Computer Readable Copy
  - b. ☐ Paper Copy (identical to computer copy)
  - c. ☐ Statement verifying identity of above copies

## ACCOMPANYING APPLICATION PARTS

8. ☐ Assignment Papers (cover sheet & document(s))
9. ☒ 37 CFR 3.73(b) Statement (when there is an assignee) ☐ Power of Attorney
10. ☐ English Translation Document (if applicable)
11. ☒ Information Disclosure Statement (IDS)/PTO-1449 ☐ Copies of IDS Citations
12. ☒ Preliminary Amendment
13. ☒ Return Receipt Postcard (MPEP 503)  
(Should be specifically itemized)
14. ☐ Small Entity ☐ Statement filed in prior application, Status still proper and desired
15. ☐ Certified Copy of Priority Document(s)  
(if foreign priority is claimed)
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Substitute Drawing Request

17. If a CONTINUING APPLICATION, check appropriate box and supply the requisite information:

☒ Continuation ☐ Divisional ☐ Continuation-in-part (CIP) of prior application No: 08/696,243

## 18. CORRESPONDENCE ADDRESS

☒ Customer Number or Bar Code Label

021567

or ☐ Correspondence address below

(Insert Customer No. or Attach bar code label here)

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COUNTRY	U.S.A.	TELEPHONE	(509) 624-4276	FAX	(509) 838-3424

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**FEE TRANSMITTAL**Note: Effective October 1, 1997.  
Patent fees are subject to annual revision.**TOTAL AMOUNT OF PAYMENT (\$)** 838.00**Complete if Known**

<b>Application Number</b>	PRIORITY 08/696,243
<b>Filing Date</b>	PRIORITY Aug. 13, 1996
<b>First Named Inventor</b>	Klaus F. Schuegraf
<b>Group Art Unit</b>	PRIORITY 2813
<b>Examiner Name</b>	PRIORITY M. Whipple
<b>Attorney Docket Number</b>	MI22-1098

**METHOD OF PAYMENT (check one)**1. ☒ The Commissioner is hereby authorized to charge indicated fees and credit any over payments to:Deposit  
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23-0925

Wells, St. John et al.

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37 CFR 1.16 and 1.17☐Charge the Issue Fee Set in  
37 CFR 1.18 at the Mailing of the  
Notice of Allowance2. ☒ Payment Enclosed:☒ Check☐ Money  
Order☐ Other**FEE CALCULATION****1. FILING FEE**

Large Entity Fee Code (\$)	Small Entity Fee Code (\$)	Fee Description	Fee Paid
101 790	201 395	Utility filing fee	760
106 330	206 165	Design filing fee	
107 540	207 270	Plant filing fee	
108 790	208 395	Reissue filing fee	
114 150	214 75	Provisional filing fee	
<b>SUBTOTAL (1)</b>			<b>(\$)</b> 760

**2. CLAIMS**

	Extra	Fee from below	Fee Paid
Total Claims 10 -20 = 0	<input checked="" type="checkbox"/>		
Independent Claims 4 -3 = 1	<input checked="" type="checkbox"/>	78	78
Multiple Dependent Claims	<input checked="" type="checkbox"/>		

Large Entity Fee Code (\$)	Small Entity Fee Code (\$)	Fee Description
103 22	203 11	Claims in excess of 20
102 82	202 41	Independent claims in excess of 3
104 270	204 135	Multiple dependent claim
109 82	209 41	Reissue independent claims over original patent
110 22	210 11	Reissue claims in excess of 20 and over original patent
<b>SUBTOTAL (2)</b>		

**SUBTOTAL (2)** (\$)**FEE CALCULATION (continued)****3. ADDITIONAL FEES**

Large Entity Fee Code (\$)	Small Entity Fee Code (\$)	Fee Description	Fee Paid
105 130	205 65	Surcharge - late filing fee or oath	0
127 50	227 25	Surcharge - late provisional filing fee or cover sheet	0
139 130	139 130	Non-English specification	0
147 2,520	147 2,520	For filing a request for reexamination	0
112 920*	112 920*	Requesting publication of SIR prior to Examiner action	0
113 1,840*	113 1,840*	Requesting publication of SIR after Examiner action	0
115 110	215 55	Extension for reply within first month	0
116 400	216 200	Extension for reply within second month	0
117 950	217 475	Extension for reply within third month	0
118 1,510	218 755	Extension for reply within fourth month	0
128 2,060	228 1,030	Extension for reply within fifth month	0
119 310	219 155	Notice of Appeal	0
120 310	220 155	Filing a brief in support of an appeal	0
121 270	221 135	Request for oral hearing	0
138 1,510	138 1,510	Petition to institute a public use proceeding	0
140 110	240 55	Petition to revive - unavoidable	0
141 1,320	241 660	Petition to revive - unintentional	0
142 1,320	242 660	Utility issue fee (or reissue)	0
143 450	243 225	Design issue fee	0
144 670	244 335	Plant issue fee	0
122 130	122 130	Petitions to the Commissioner	0
123 50	123 50	Petitions related to provisional applications	0
126 240	126 240	Submission of Information Disclosure Stmt	0
581 40	581 40	Recording each patent assignment per property (times number of properties)	0
146 790	246 395	Filing a submission after final rejection (37 CFR 1.129(a))	0
149 790	249 395	For each additional invention to be examined (37 CFR 1.129(b))	0
Other fee (specify) _____			0
Other fee (specify) _____			0
<b>SUBTOTAL(3)</b>			<b>(\$)</b> 0

\* Reduced by Basic Filing Fee Paid

**SUBMITTED BY**Typed or  
Printed Name Lance R. Sadler

Signature

Date

12/15/98

**Complete (if applicable)**

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EL169836626

1                   **IN THE UNITED STATES PATENT AND TRADEMARK OFFICE**

2    Priority Application Serial No. .... 08/696,243  
3    Priority Filing Date ..... 08/13/96  
4    Inventor ..... Schuegraf  
5    Assignee ..... Micron Technology, Inc.  
6    Priority Group Art Unit ..... 2813  
7    Priority Examiner ..... M. Whipple  
8    Attorney's Docket No. .... MI22-1098  
9    Title: Semiconductor Processing Methods of Chemical Vapor Depositing SiO<sub>2</sub> on  
10       a Substrate

11                                   **PRELIMINARY AMENDMENT**

12    To:           Box PATENT APPLICATION  
13               Assistant Commissioner for Patents  
14               Washington, D.C. 20231

15    From:       Lance R. Sadler (Tel. 509-624-4276; Fax 509-838-3424)  
16               Wells, St. John, Roberts, Gregory & Matkin P.S.  
17               601 W. First Avenue, Suite 1300  
18               Spokane, WA 99201-3817

19    Sir:

20               Applicant preliminarily amends as follows:

21                                   **AMENDMENTS**

22    **In the Specification**

23               On page 1, before the "Technical Field" section, insert the  
24               following section:

25                               **--RELATED PATENT DATA**

26               This patent resulted from a continuation application of U.S. Patent  
27               Application Serial No. 08/696,243, filed August 13, 1996, entitled  
28               "Semiconductor Processing Methods of Chemical Vapor Depositing SiO<sub>2</sub>

1 on a Substrate", naming Klaus F. Schuegraf as inventor, and which is  
2 now U.S. Patent No. \_\_\_\_\_ the disclosure of which is  
3 incorporated by reference.--  
4

5 **In the Claims**

6 Cancel claims 1-38 without prejudice.  
7

8 **New Claims**

9 Add new claims 39-48 as follows:  
10

11 39. A semiconductor processing method of depositing  $\text{SiO}_2$  on  
12 a substrate within a chemical vapor deposition reactor comprising feeding  
13 at least one of  $\text{H}_2\text{O}$  and  $\text{H}_2\text{O}_2$  into the reactor while feeding an  
14 organic silicon precursor, wherein the at least one of  $\text{H}_2\text{O}$  and  $\text{H}_2\text{O}_2$   
15 is fed into the reactor separately from the organic silicon precursor, and  
16 under conditions which are effective to reduce the decomposition rate  
17 of the organic silicon precursor.  
18

19 40. The semiconductor processing method of claim 39, wherein  
20 the at least one of  $\text{H}_2\text{O}$  and  $\text{H}_2\text{O}_2$  comprises less than about 50% by  
21 volume of material injected into the reactor.  
22  
23

1           41. The semiconductor processing method of claim 40, wherein  
2 the at least one of  $H_2O$  and  $H_2O_2$  comprises between about 5% to  
3 15% by volume of material injected into the reactor.

4  
5           42. The semiconductor processing method of claim 40, wherein  
6 the at least one of  $H_2O$  and  $H_2O_2$  comprises less than about 5% by  
7 volume of material injected into the reactor.

8  
9           43. A semiconductor processing method of forming silicon dioxide  
10 comprising feeding at least one of  $H_2O$  and  $H_2O_2$  into a chemical vapor  
11 deposition reactor with an organic silicon precursor under conditions  
12 effective to decompose the organic silicon precursor into silicon dioxide  
13 and reduce formation of undesired reaction intermediates in the reactor  
14 during the decomposition reaction, wherein the at least one of  $H_2O$   
15 and  $H_2O_2$  is fed into the reactor separately from the organic silicon  
16 precursor, said organic silicon precursor being the only silicon containing  
17 precursor which is fed into the reactor to form said silicon dioxide.

18  
19           44. The semiconductor processing method of claim 43, wherein  
20 the organic silicon precursor is selected from the group consisting of:  
21 silane, tetraethoxysilane (TEOS), diethylsilane (DES), tetramethylcyclo-  
22 tetrasiloxane (TMCTS), fluorotriethoxysilane (FTES), and  
23 fluorotrialkoxysilane (FTAS).

1           45. The semiconductor processing method of claim 43, wherein  
2 the chemical vapor deposition reactor is a hot wall reactor.  
3

4           46. The semiconductor processing method of claim 43, wherein  
5 the chemical vapor deposition reactor is a cold hot reactor.  
6

7           47. A semiconductor processing method of chemical vapor  
8 depositing  $\text{SiO}_2$  on a substrate comprising:

9           placing a substrate within a chemical vapor deposition reactor;

10           feeding an organic silicon precursor into the chemical vapor  
11 deposition reactor having the substrate positioned therein under  
12 conditions effective to decompose the precursor into  $\text{SiO}_2$  which deposits  
13 on the substrate and into a gaseous oxide of hydrogen; and

14           feeding an additional quantity of the gaseous oxide of hydrogen  
15 into the reactor while feeding the organic silicon precursor into the  
16 reactor, wherein the organic silicon precursor and the additional quantity  
17 of the gaseous oxide of hydrogen are fed into the reactor from separate  
18 feed streams and under conditions which are effective to reduce the  
19 decomposition rate of the organic silicon precursor into the  $\text{SiO}_2$ .  
20  
21  
22  
23

1           48. A semiconductor processing method of chemical vapor  
2 depositing SiO<sub>2</sub> on a substrate comprising:

3           placing a substrate within a hot wall low pressure chemical vapor  
4 deposition reactor;

5           feeding an organic silicon precursor into the hot wall chemical  
6 vapor deposition reactor having the substrate positioned therein under  
7 conditions effective to decompose the precursor into SiO<sub>2</sub> which deposits  
8 on the substrate and into a gaseous oxide of hydrogen; and

9           feeding an additional quantity of the gaseous oxide of hydrogen  
10 into the hot wall low pressure chemical vapor deposition reactor while  
11 feeding the organic silicon precursor into the reactor, wherein the  
12 organic silicon precursor and the additional quantity of the gaseous oxide  
13 of hydrogen are fed into the reactor from separate feed streams.  
14  
15  
16  
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REMARKS

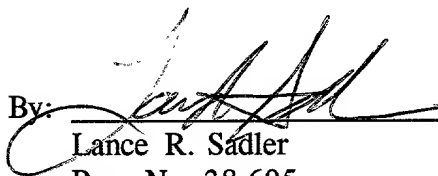
Claims 1-38 have been canceled without prejudice. Claims 39-48 have been added and remain in the application for consideration.

Respectfully submitted,

Dated:

12/15/98

By:



Lance R. Sadler  
Reg. No. 38,605



IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

APPLICATION FOR LETTERS PATENT

\* \* \* \* \*

Semiconductor Processing Methods Of Chemical  
Vapor Depositing SiO<sub>2</sub> On A Substrate

\* \* \* \* \*

INVENTOR

Klaus F. Schuegraf

ATTORNEY'S DOCKET NO. MI22-482

EL169836626  
EM189770036

1 **TECHNICAL FIELD**

2 This invention relates to semiconductor processing methods of  
3 chemical vapor depositing  $\text{SiO}_2$  on a substrate.

4  
5 **BACKGROUND OF THE INVENTION**

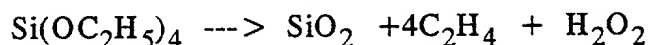
6 Chemical vapor deposited (CVD)  $\text{SiO}_2$  films and their binary and  
7 ternary silicates find wide use in VLSI processing. These materials find  
8 use as insulators between polysilicon and metal layers, between metal  
9 layers in multilevel metal systems, as diffusion sources, as diffusion and  
10 implantation masks, as capping layers to prevent outdiffusion, and as  
11 final passivation layers.

12 The manner in which a thin film covers or conforms to the  
13 underlying features on a substrate is an important characteristic in  
14 semiconductor processing. Conformal coverage refers to coverage in  
15 which equal film thickness exists over all substrate topography regardless  
16 of its slope, i.e. vertical and horizontal substrate surfaces are coated  
17 with equal film thickness.

18 One manner of effecting the deposition of  $\text{SiO}_2$  on a substrate  
19 is through pyrolysis of an organic silicon precursor in a CVD reactor  
20 to form  $\text{SiO}_2$ . A typical organic silicon precursor is tetraethoxysilane  
21 or TEOS which is represented by the chemical formula  $\text{Si}(\text{OC}_2\text{H}_5)_4$ .  
22 A typical reactor used to effect the pyrolysis of organic silicon  
23 precursors is a low pressure CVD reactor or LPCVD reactor. LPCVD  
24

1 reactors include both hot wall and cold wall reactors. In hot wall  
2 reactors, wafers can be heated utilizing radiant heat supplied from  
3 resistance-heated coils. In cold wall reactors, wafers can be heated  
4 utilizing infrared lamps or rf induction.

5 LPCVD reactors are typically operated at pressures of around  
6 0.25-2.0 Torr and temperatures of around 550° C to 800° C, although  
7 such parameters may vary depending on a number of different  
8 conditions including the particular types of reactants used. The  
9 stoichiometry of decomposition of TEOS within an LPCVD reactor may  
10 be simplistically written as:



12 Typically, however, intermediates are formed in the above reaction  
13 which include di-ethoxysilane ( $\text{Si(OC}_2\text{H}_5)_3\text{OH}$ ) and tri-ethoxysilane  
14 ( $\text{Si(OC}_2\text{H}_5)_2(\text{OH})_2$ ). Further, other reaction by-products are formed.

15 One problem facing the semiconductor wafer processor is achieving  
16 adequate and conformal step coverage of deposited  $\text{SiO}_2$  into very deep  
17 and narrow contact openings or other so-called high aspect ratio  
18 topographies. One such substrate surface topography is depicted in  
19 Figs. 1 and 2 and designated generally by reference numeral 10.  
20 Topography 10 is defined by a deep trench 12 into which an  $\text{SiO}_2$  layer  
21 14 has been deposited as by CVD of a suitable organic silicon  
22 precursor such as TEOS.

1 Fig. 1 illustrates a situation in which adequate conformality has  
2 been achieved as evidenced by the uniformity or substantial uniformity  
3 in thickness of layer 14 over the substrate surface, and particularly  
4 within trench 12. Fig. 2 illustrates a situation in which inadequate  
5 conformality has resulted in non-uniformity in the thickness of layer 14,  
6 particularly at and near the bottom of trench 12. Such is an  
7 undesirable condition.

8 One source of inadequate conformality of  $\text{SiO}_2$  on a substrate  
9 surface is premature formation of undesirable intermediates which react  
10 to form  $\text{SiO}_2$  at higher topographical elevations on a substrate surface.  
11 Consequently, such intermediates never reach the bottom of a particular  
12 substrate feature, such as trench 12 of Fig. 2, so that lesser degrees of  
13  $\text{SiO}_2$  are formed thereon.

14 One method to improve step coverage has been to increase  
15 pressures in the CVD reactor. By doing so, the partial pressure of the  
16 organic silicon precursor, such as TEOS, is increased, while the partial  
17 pressure of the intermediates is not. The increase in organic silicon  
18 precursor partial pressure results in improved step coverage because the  
19 precursor has a more favorable sticking coefficient as compared with  
20 the intermediates.

21 Another attempt to increase step coverage has been to introduce  
22 ethylene ( $\text{C}_2\text{H}_4$ ) into the reactor with the precursor to inhibit the  
23 premature formation of intermediates. Unfortunately, great success has  
24

not been achieved due to significant degradation of deposition rates stemming from competitive absorption relative to the substrate surface as between the ethylene and the precursor.

This invention grew out of the need to provide improved step coverage of LPCVD  $\text{SiO}_2$  over high aspect ratio substrate topography.

### SUMMARY OF THE INVENTION

The invention provides semiconductor processing methods of depositing  $\text{SiO}_2$  on a substrate.

In a preferred aspect, the invention provides methods of reducing the formation of undesired reaction intermediates in a chemical vapor deposition (CVD) decomposition reaction. In one implementation, the method is performed by feeding at least one of  $\text{H}_2\text{O}$  and  $\text{H}_2\text{O}_2$  into a reactor with an organic silicon precursor. For example, in one exemplary implementation, such components are, in gaseous form, fed separately into the reactor. In another exemplary implementation, such components are combined in liquid form prior to introduction into the reactor, and thereafter rendered into a gaseous form for provision into the reactor. The invention can be practiced with or in both hot wall and cold wall CVD systems.

## BRIEF DESCRIPTION OF THE DRAWINGS

Preferred embodiments of the invention are described below with reference to the following accompanying drawings.

Fig. 1 illustrates a so-called high aspect ratio semiconductor topography in the form of a trench into which silicon dioxide has been deposited achieving adequate conformal coverage.

Fig. 2 illustrates a high aspect ratio semiconductor topography similar to Fig. 1, only one in which inadequate conformal coverage has been achieved.

Fig. 3 is a schematic diagram of a chemical vapor deposition system which may be used in conjunction with one preferred aspect of the invention.

Fig. 4 is a schematic diagram of a chemical vapor deposition system which may be used in conjunction with another preferred aspect of the invention.

## DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

This disclosure of the invention is submitted in furtherance of the constitutional purposes of the U.S. Patent Laws "to promote the progress of science and useful arts" (Article 1, Section 8).

In accordance with one aspect of the invention, a semiconductor processing method of chemical vapor depositing  $\text{SiO}_2$  on a substrate comprises:

placing a substrate within a chemical vapor deposition reactor;

feeding an organic silicon precursor into the chemical vapor deposition reactor having the substrate positioned therein under conditions effective to decompose the precursor into  $\text{SiO}_2$  which deposits on the substrate and into a gaseous oxide of hydrogen; and

feeding an additional quantity of the gaseous oxide of hydrogen into the reactor while feeding the organic silicon precursor to the reactor.

In accordance with another aspect of the invention, a semiconductor processing method of reducing the decomposition rate of an organic silicon precursor in a chemical vapor deposition process of depositing  $\text{SiO}_2$  on a substrate within a chemical vapor deposition reactor comprises feeding at least one of  $\text{H}_2\text{O}$  and  $\text{H}_2\text{O}_2$  into the reactor while feeding the organic silicon precursor.

1 In accordance with another aspect of the invention, a  
2 semiconductor processing method of chemical vapor depositing  $\text{SiO}_2$  on  
3 a substrate comprises:

4 placing a substrate within a chemical vapor deposition reactor; and  
5 feeding an organic silicon precursor and feeding an oxide of  
6 hydrogen into the chemical vapor deposition reactor having the substrate  
7 positioned therein under conditions effective to deposit an  $\text{SiO}_2$  layer  
8 on the substrate.

9 In accordance with another aspect of the invention, a  
10 semiconductor processing method of reducing the formation of undesired  
11 reaction intermediates in a chemical vapor deposition decomposition  
12 reaction of an organic silicon precursor into silicon dioxide within a  
13 chemical vapor deposition reactor comprises feeding at least one of  $\text{H}_2\text{O}$   
14 and  $\text{H}_2\text{O}_2$  into the reactor with the organic silicon precursor.

15 Figs. 3 and 4 show schematic diagrams of a different chemical  
16 vapor deposition (CVD) systems both of which are designated at 16.  
17 The preferred semiconductor processing methods may be carried out in  
18 either system in accordance with the description below. The system of  
19 Fig. 3 is configured slightly differently from the system of Fig. 4 as will  
20 become apparent below. Preferably, CVD systems 16 are low pressure  
21 chemical vapor deposition (LPCVD) hot wall systems, although other  
22 CVD systems, such as cold wall systems can be used as will become  
23 apparent. The illustrated and preferred hot wall systems 16 include a  
24



1 CVD reactor 18 which is configured to carry out depositions at  
2 temperatures between around 640° C to 900° C, and at pressures  
3 between 100 mTorr to 3 Torr. Various gases can be supplied to  
4 reactor 18 from one or more gas sources or bubblers, such as those  
5 shown at 20. Such gas sources or bubblers typically hold or contain  
6 a liquid mixture which is heated to produce a gas. Such gas from gas  
7 sources 20 enters CVD reactor 18 where exposure to temperature and  
8 pressure conditions effect deposition of a material, preferably SiO<sub>2</sub>, on  
9 a semiconductor or wafer substrate therewithin. More than one gas  
10 source (Fig. 4) may be used. Inside of CVD reactor 18, a  
11 semiconductor wafer holder 22 is provided for holding a plurality of  
12 semiconductor wafers or substrates 24. After suitable deposition has  
13 occurred, gaseous by-products are exhausted, together with unused  
14 reactant and/or diluent gases through exhaust port 26. Reactant gases  
15 may be carried by inert diluent or carrier gases such as H<sub>2</sub>, N<sub>2</sub> or Ar.

16 Fig. 3 shows system 16 configured for carrying out one preferred  
17 semiconductor processing method of chemical vapor depositing SiO<sub>2</sub> on  
18 a substrate. Accordingly, system 16 includes a gas source 28. An  
19 example of a suitable gas source is a bubbler which contains liquid  
20 reactants which are subsequently converted into a gas for provision into  
21 a reactor, such as reactor 18. The illustrated and preferred method  
22 includes placing a substrate or substrates, such as those shown at 24,  
23 within a chemical vapor deposition reactor, such as reactor 18.

Reactants which are held in gas source 28 are then heated to produce a gas which is supplied to reactor 18 for further processing in accordance this method. One such reactant is a suitable organic silicon precursor which is preferably tetraethoxysilane or TEOS. Such precursor is fed into reactor 18 wherein substrate 24 is positioned under processing conditions, such as the temperature and pressure conditions mentioned above, which are effective to decompose the precursor into  $\text{SiO}_2$ . Although the preferred methods are described as utilizing TEOS as the preferred organic silicon precursor, other such organic silicon precursors may be used. Other precursors include: silane, diethylsilane (DES), tetramethylcyclo-tetrasiloxane (TMCTS), fluorotriethoxysilane (FTES), and fluorotrialkoxysilane (FTAS). The  $\text{SiO}_2$  deposits on substrates 24 and preferably into high-aspect topography features such as trench 12 in Fig. 1. The organic silicon precursor also decomposes into a gaseous oxide of hydrogen such as  $\text{H}_2\text{O}$  and  $\text{H}_2\text{O}_2$ . According to a preferred aspect of the invented method, another reactant, preferably either  $\text{H}_2\text{O}$  or  $\text{H}_2\text{O}_2$ , is provided in liquid form in gas source 28. Such additional quantity of the oxide of hydrogen is fed into reactor 18 in gaseous form, while feeding the organic silicon precursor into the reactor. The presence of the additional quantity of the gaseous oxide of hydrogen shifts the reaction equilibrium in the direction of the reactants, thus increasing the partial pressure of the organic silicon precursor. Such inhibits or reduces premature formation

1 of undesirable intermediates which heretofore have reduced the  
2 conformality of the deposition process.

3 Referring still to Fig. 3, quantities of TEOS and the additional  
4 quantity of the oxide of hydrogen, both in liquid form, are mixed  
5 together to form a liquid mixture. The liquid mixture formed thereby  
6 is then converted to a gaseous mixture which is thereafter fed into  
7 reactor 18. By first combining liquid forms of the oxide of hydrogen  
8 and the organic silicon precursor, and then feeding the gaseous mixture  
9 produced thereafter into the reactor, the organic silicon precursor and  
10 the additional gaseous quantity of the oxide of hydrogen are fed into  
11 the reactor together. Preferably, the quantity of organic silicon  
12 precursor, in this example TEOS, in the liquid mixture is greater by  
13 volume than the quantity of the oxide of hydrogen. Even more  
14 preferably, the liquid mixture volume comprises between about 5% to  
15 15% of the oxide of hydrogen. Volumes of the oxide of hydrogen less  
16 than about 5% can be utilized to achieve the above-described  
17 advantages. Volumes of about 0.5% or lower of either of the oxides  
18 of hydrogen may also be utilized. Conversion of the liquid mixture to  
19 the gaseous mixture preferably takes place at bubbler temperatures  
20 between about 65° to 80°C with a preferred temperature of about 75°C.  
21 Thereafter, the gaseous mixture is fed into reactor 18 where it is  
22 reacted to deposit SiO<sub>2</sub> on substrates 24 therewithin.

1 The above described method is one in which the organic silicon  
2 precursor and the oxide of hydrogen are first mixed in liquid form to  
3 form a liquid mixture. The liquid mixture is then subjected to  
4 conditions effective to convert it into a gas which is thereafter fed into  
5 the illustrated and preferred hot wall CVD reactor for subsequent  
6 deposition processing at temperatures between around 640°C to 900°C.  
7 The gaseous mixture is fed into the reactor from a common feed  
8 stream.

9 The above described method can also be employed in cold wall  
10 LPCVD systems under the following preferred pressure, temperature and  
11 other relevant operating conditions. Cold wall deposition conditions or  
12 parameters include pressure conditions of around 10 Torr up to an  
13 upper limit of around 80 Torr. A preferred temperature for cold wall  
14 processing is around 400°C with rf plasma power at 600W. Further, in  
15 accordance with this aspect of the invention, O<sub>2</sub> and He flows  
16 respectively, are at 600 sccm and 775 sccm. The preferred organic  
17 precursor is TEOS which is delivered by liquid injection at 975 sccm.  
18 Additionally, a wafer gap to susceptor is around 230 mils. Under the  
19 above conditions, a resulting SiO<sub>2</sub> deposition rate of around 7000  
20 Angstroms/min is possible.

21 Fig. 4 illustrates schematically a CVD system in which two gas  
22 sources or bubblers 30, 32 are shown. Preferably, one of the gas  
23 sources contains the organic silicon precursor, preferably TEOS, and the  
24

1 other gas source contains the additional quantity of the oxide of  
2 hydrogen, either of  $H_2O$  and/or  $H_2O_2$ . In such system, reactor 18 is  
3 separately fed with such gaseous reactants. A preferred concentration  
4 of gaseous material provided into reactor 18 comprises less than  
5 about 50% by volume of the  $H_2O$  and/or  $H_2O_2$ . Even more preferably,  
6 the volume of material injected into the reactor comprises between  
7 about 5% to 15% by volume of the  $H_2O$  and/or  $H_2O_2$ . Quantities of  
8  $H_2O$  and  $H_2O_2$  less than about 5% of the volume of material injected  
9 into the reactor may be utilized to achieve the above-described  
10 advantages. Volumes of about 0.5% or lower of either of the oxides  
11 of hydrogen can reduce the decomposition rate of the organic silicon  
12 precursor sufficiently to allow CVD depositing of  $SiO_2$  on a silicon  
13 substrate.

14 The above described method is one in which the reactants are  
15 provided in separate bubblers or gas sources, and subjected to  
16 conditions effective to convert each to a separate gas. Each separate  
17 gas is then separately fed into the reactor and exposed to temperature  
18 and pressure conditions effective to deposit an  $SiO_2$  layer on the wafers  
19 or substrates held therewithin. The gaseous mixtures are fed into the  
20 reactor from separate feed streams. As in the first-described method,  
21 the above described method may be utilized in cold wall LPCVD  
22 systems under conditions which are the same as or similar to those  
23 mentioned above.  
24

1 In compliance with the statute, the invention has been described  
2 in language more or less specific as to structural and methodical  
3 features. It is to be understood, however, that the invention is not  
4 limited to the specific features shown and described, since the means  
5 herein disclosed comprise preferred forms of putting the invention into  
6 effect. The invention is, therefore, claimed in any of its forms or  
7 modifications within the proper scope of the appended claims  
8 appropriately interpreted in accordance with the doctrine of equivalents.  
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CLAIMS:

1. A semiconductor processing method of chemical vapor depositing  $\text{SiO}_2$  on a substrate comprising:

placing a substrate within a chemical vapor deposition reactor;

feeding an organic silicon precursor into the chemical vapor deposition reactor having the substrate positioned therein under conditions effective to decompose the precursor into  $\text{SiO}_2$  which deposits on the substrate and into a gaseous oxide of hydrogen; and

feeding an additional quantity of the gaseous oxide of hydrogen into the reactor while feeding the organic silicon precursor into the reactor.

2. The semiconductor processing method of claim 1, wherein the organic silicon precursor and the additional quantity of the gaseous oxide of hydrogen are fed into the reactor from separate feed streams.

3. The semiconductor processing method of claim 1, wherein the organic silicon precursor and the additional quantity of the gaseous oxide of hydrogen are fed into the reactor from a common feed stream.

1           4.     The semiconductor processing method of claim 1, wherein  
2 the feeding steps collectively comprise:

3           mixing a quantity of the organic silicon precursor in liquid form  
4 and a quantity of the oxide of hydrogen in liquid form to form a liquid  
5 mixture;

6           converting the liquid mixture to a gaseous mixture; and

7           feeding the gaseous mixture into the reactor.  
8

9           5.     The semiconductor processing method of claim 1, wherein  
10 the feeding steps collectively comprise:

11           mixing a quantity of the organic silicon precursor in liquid form  
12 and a quantity of the oxide of hydrogen in liquid form to form a liquid  
13 mixture, the quantity of the organic silicon precursor being greater by  
14 volume than the quantity of the oxide of hydrogen;

15           converting the liquid mixture to a gaseous mixture; and

16           feeding the gaseous mixture into the reactor.  
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1           6.    The semiconductor processing method of claim 1, wherein  
2   the feeding steps collectively comprise:

3           mixing a quantity of the organic silicon precursor in liquid form  
4   and a quantity of the oxide of hydrogen in liquid form to form a liquid  
5   mixture, the quantity of the oxide of hydrogen comprising between about  
6   5%-15% of the liquid mixture volume;

7           converting the liquid mixture to a gaseous mixture; and  
8           feeding the gaseous mixture into the reactor.

9  
10          7.    The semiconductor processing method of claim 1, wherein  
11   the feeding steps collectively comprise:

12          mixing a quantity of the organic silicon precursor in liquid form  
13   and a quantity of the oxide of hydrogen in liquid form to form a liquid  
14   mixture;

15          converting the liquid mixture to a gaseous mixture, the converting  
16   step including heating the liquid mixture to a temperature of between  
17   about 65° C to 80° C; and

18          feeding the gaseous mixture into the reactor.  
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1           8.     The semiconductor processing method of claim 1, wherein  
2 the feeding steps collectively comprise:

3           mixing a quantity of the organic silicon precursor in liquid form  
4 and a quantity of the oxide of hydrogen in liquid form to form a liquid  
5 mixture, the quantity of the organic silicon precursor being greater by  
6 volume than the quantity of the oxide of hydrogen;

7           converting the liquid mixture to a gaseous mixture, the converting  
8 step including heating the liquid mixture to a temperature of between  
9 about 65° C to 80° C; and

10          feeding the gaseous mixture into the reactor.  
11

12           9.     The semiconductor processing method of claim 1, wherein  
13 the feeding steps collectively comprise:

14          mixing a quantity of the organic silicon precursor in liquid form  
15 and a quantity of the oxide of hydrogen in liquid form to form a liquid  
16 mixture, the quantity of the oxide of hydrogen comprising between about  
17 5%-15% of the liquid mixture volume;

18          converting the liquid mixture to a gaseous mixture, the converting  
19 step including heating the liquid mixture to a temperature of between  
20 about 65° C to 80° C; and

21          feeding the gaseous mixture into the reactor.  
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1           10. The semiconductor processing method of claim 1 wherein the  
2 organic silicon precursor is selected from the group consisting of silane,  
3 tetraethoxysilane (TEOS), diethylsilane (DES), tetramethylcyclo-  
4 tetrasiloxane (TMCTS), fluorotriethoxysilane (FTES), and  
5 fluorotrialkoxysilane (FTAS).  
6

7           11. The semiconductor processing method of claim 1, wherein  
8 the chemical vapor deposition reactor is a hot wall reactor.  
9

10           12. The semiconductor processing method of claim 1, wherein  
11 the chemical vapor deposition reactor is a cold wall reactor.  
12

13           13. A semiconductor processing method of reducing the  
14 decomposition rate of an organic silicon precursor in a chemical vapor  
15 deposition process of depositing  $\text{SiO}_2$  on a substrate within a chemical  
16 vapor deposition reactor comprising feeding at least one of  $\text{H}_2\text{O}$  and  
17  $\text{H}_2\text{O}_2$  into the reactor while feeding the organic silicon precursor.  
18

19           14. The semiconductor processing method of claim 13, wherein  
20 the at least one of  $\text{H}_2\text{O}$  and  $\text{H}_2\text{O}_2$  is fed into the reactor separately  
21 from the organic silicon precursor.  
22  
23  
24

15. The semiconductor processing method of claim 13, wherein the at least one of  $H_2O$  and  $H_2O_2$  is injected into the reactor separately from the organic silicon precursor, and comprises less than about 50% by volume of material injected into the reactor.

16. The semiconductor processing method of claim 13, wherein the at least one of  $H_2O$  and  $H_2O_2$  is injected into the reactor separately from the organic silicon precursor, and comprises between about 5% to 15% by volume of material injected into the reactor.

17. The semiconductor processing method of claim 13, wherein the at least one of  $H_2O$  and  $H_2O_2$  is injected into the reactor separately from the organic silicon precursor, and comprises less than about 5% by volume of material injected into the reactor.

18. The semiconductor processing method of claim 13, wherein the feeding steps collectively comprise:

mixing a quantity of the organic silicon precursor in liquid form and a quantity of the at least one of  $H_2O$  and  $H_2O_2$  in liquid form to form a liquid mixture;

converting the liquid mixture to a gaseous mixture; and

feeding the gaseous mixture into the reactor.

1           19. The semiconductor processing method of claim 13, wherein  
2 the feeding steps collectively comprise:

3           mixing a quantity of the organic silicon precursor in liquid form  
4 and a quantity of the at least one of  $H_2O$  and  $H_2O_2$  in liquid form  
5 to form a liquid mixture, the liquid mixture comprising no less than  
6 about 0.5% by volume of the at least one of  $H_2O$  and  $H_2O_2$ ;

7           converting the liquid mixture to a gaseous mixture; and  
8           feeding the gaseous mixture into the reactor.  
9

10          20. The semiconductor processing method of claim 13, wherein  
11 the feeding steps collectively comprise:

12          mixing a quantity of the organic silicon precursor in liquid form  
13 and a quantity of the at least one of  $H_2O$  and  $H_2O_2$  in liquid form  
14 to form a liquid mixture, the liquid mixture comprising between about  
15 5% to 15% by volume of the at least one of  $H_2O$  and  $H_2O_2$ ;

16          converting the liquid mixture to a gaseous mixture; and  
17          feeding the gaseous mixture into the reactor.  
18

19          21. The semiconductor processing method of claim 13, wherein  
20 the organic silicon precursor is selected from the group consisting of  
21 silane, tetraethoxysilane (TEOS), diethylsilane (DES), tetramethylcyclo-  
22 tetrasiloxane (TMCTS), fluorotriethoxysilane (FTES), and  
23 fluorotrialkoxysilane (FTAS).  
24

1           22. The semiconductor processing method of claim 13, wherein  
2 the chemical vapor deposition reactor is a hot wall reactor.  
3

4           23. The semiconductor processing method of claim 13, wherein  
5 the chemical vapor deposition reactor is a cold wall reactor.  
6

7           24. A semiconductor processing method of chemical vapor  
8 depositing  $\text{SiO}_2$  on a substrate comprising:

9           placing a substrate within a chemical vapor deposition reactor; and

10           feeding an organic silicon precursor and feeding an oxide of  
11 hydrogen into the chemical vapor deposition reactor having the substrate  
12 positioned therein under conditions effective to deposit an  $\text{SiO}_2$  layer  
13 on the substrate.  
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1           25. The semiconductor processing method of claim 24, wherein  
2 the feeding steps collectively comprise:

3           mixing a quantity of the organic silicon precursor in liquid form  
4 and a quantity of the oxide of hydrogen in liquid form to form a liquid  
5 mixture, the liquid mixture comprising less than about 15% by volume  
6 of the oxide of hydrogen;

7           heating the liquid mixture to a temperature sufficient to produce  
8 a gas containing at least some organic silicon precursor and at least  
9 some oxide of hydrogen; and

10          feeding the produced gas into the reactor.  
11

12           26. The semiconductor processing method of claim 24, wherein  
13 the volume of material injected into the reactor has no more than  
14 about 15% by volume of the oxide of hydrogen.  
15

16           27. The semiconductor processing method of claim 24, wherein  
17 the volume of material injected into the reactor has between about 5%  
18 to 15% by volume of the oxide of hydrogen.  
19

20           28. The semiconductor processing method of claim 24, wherein  
21 the volume of material injected into the reactor has between about  
22 0.5% to 5% by volume of the oxide of hydrogen.  
23  
24

1           29. The semiconductor processing method of claim 24, wherein  
2 the organic silicon precursor is selected from the group consisting of:  
3 silane, tetraethoxysilane (TEOS), diethylsilane (DES), tetramethylcyclo-  
4 tetrasiloxane (TMCTS), fluorotriethoxysilane (FTES), and  
5 fluorotrialkoxysilane (FTAS).  
6

7           30. The semiconductor processing method of claim 24, wherein  
8 the chemical vapor deposition reactor is a hot wall reactor.  
9

10          31. The semiconductor processing method of claim 24, wherein  
11 the chemical vapor deposition reactor is a cold wall reactor.  
12

13          32. A semiconductor processing method of reducing the  
14 formation of undesired reaction intermediates in a chemical vapor  
15 deposition decomposition reaction of an organic silicon precursor into  
16 silicon dioxide within a chemical vapor deposition reactor comprising  
17 feeding at least one of  $H_2O$  and  $H_2O_2$  into the reactor with the  
18 organic silicon precursor.  
19

20          33. The semiconductor processing method of claim 32 wherein  
21 the at least one of  $H_2O$  and  $H_2O_2$  is fed into the reactor separately  
22 from the organic silicon precursor.  
23  
24



1           34. The semiconductor processing method of claim 32 wherein  
2 the at least one of  $H_2O$  and  $H_2O_2$  is first combined with the organic  
3 silicon precursor, and then fed into the reactor with the organic silicon  
4 precursor.

5  
6           35. The semiconductor processing method of claim 32, wherein  
7 the organic silicon precursor is selected from the group consisting of:  
8 silane, tetraethoxysilane (TEOS), diethylsilane (DES), tetramethylcyclo-  
9 tetrasiloxane (TMCTS), fluorotriethoxysilane (FTES), and  
10 fluorotrialkoxysilane (FTAS).

11  
12           36. The semiconductor processing method of claim 32, wherein  
13 the chemical vapor deposition reactor is a hot wall reactor.

14  
15           37. The semiconductor processing method of claim 32, wherein  
16 the chemical vapor deposition reactor is a cold hot reactor.

1           38. A semiconductor processing method of chemical vapor  
2 depositing  $\text{SiO}_2$  on a substrate comprising:

3           placing a substrate within a chemical vapor deposition reactor;

4           mixing a quantity of an organic silicon precursor in liquid form  
5 and a quantity of an oxide of hydrogen in liquid form to form a liquid  
6 mixture, the organic silicon precursor being selected from the group  
7 consisting of: silane, tetraethoxysilane (TEOS), diethylsilane (DES),  
8 tetramethylcyclo-tetrasiloxane (TMCTS), fluorotriethoxysilane (FTES), and  
9 fluorotrialkoxysilane (FTAS), the oxide of hydrogen being selected from  
10 the group consisting of:  $\text{H}_2\text{O}$  and  $\text{H}_2\text{O}_2$ , the quantity of the oxide of  
11 hydrogen comprising between about 5%-15% of the liquid mixture  
12 volume;

13           converting the liquid mixture to a gaseous mixture by heating the  
14 liquid mixture to a temperature of between about  $65^\circ\text{C}$  to  $80^\circ\text{C}$ ; and  
15           feeding the gaseous mixture into the reactor.

1        ABSTRACT OF THE DISCLOSURE

2            The invention provides semiconductor processing methods of  
3        depositing  $\text{SiO}_2$  on a substrate.    In a preferred aspect, the invention  
4        provides methods of reducing the formation of undesired reaction  
5        intermediates in a chemical vapor deposition (CVD) decomposition  
6        reaction.    In one implementation, the method is performed by feeding  
7        at least one of  $\text{H}_2\text{O}$  and  $\text{H}_2\text{O}_2$  into a reactor with an organic silicon  
8        precursor.    For example, in one exemplary implementation, such  
9        components are, in gaseous form, fed separately into the reactor.    In  
10       another exemplary implementation, such components are combined in  
11       liquid form prior to introduction into the reactor, and thereafter  
12       rendered into a gaseous form for provision into the reactor.    The  
13       invention can be practiced with or in both hot wall and cold wall CVD  
14       systems.

1/2

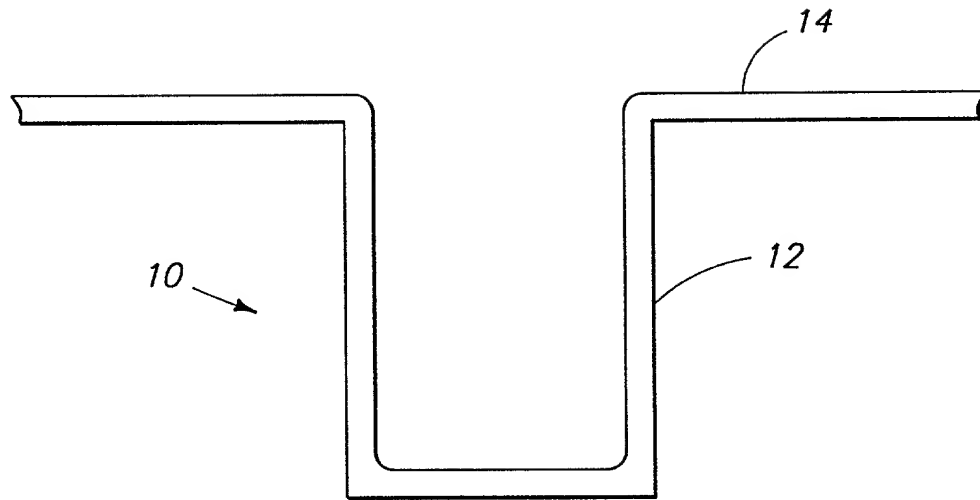


FIG. 1

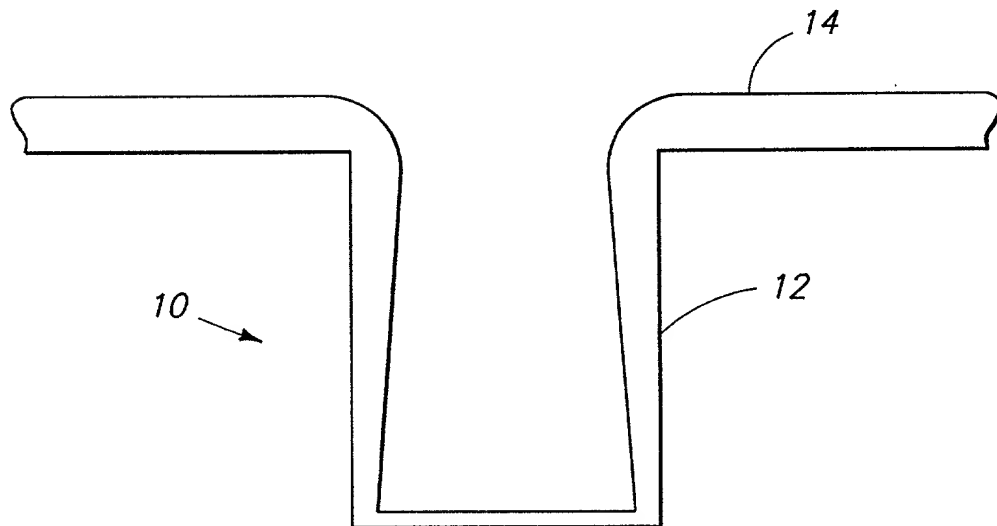
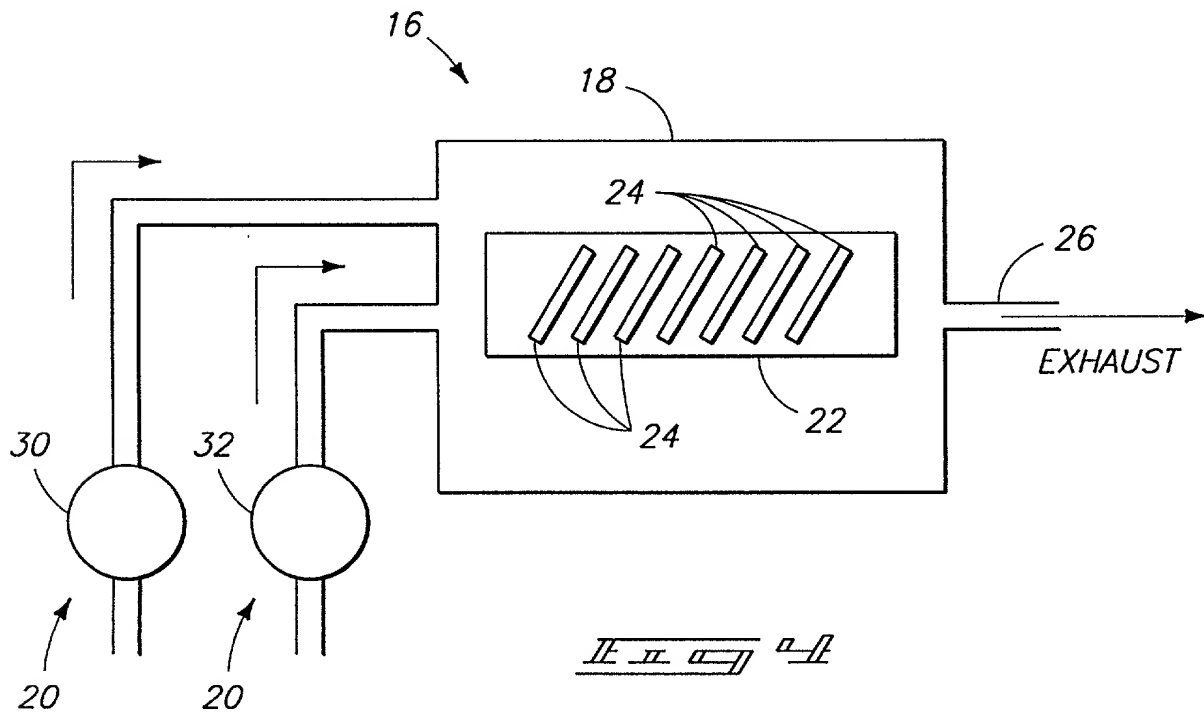
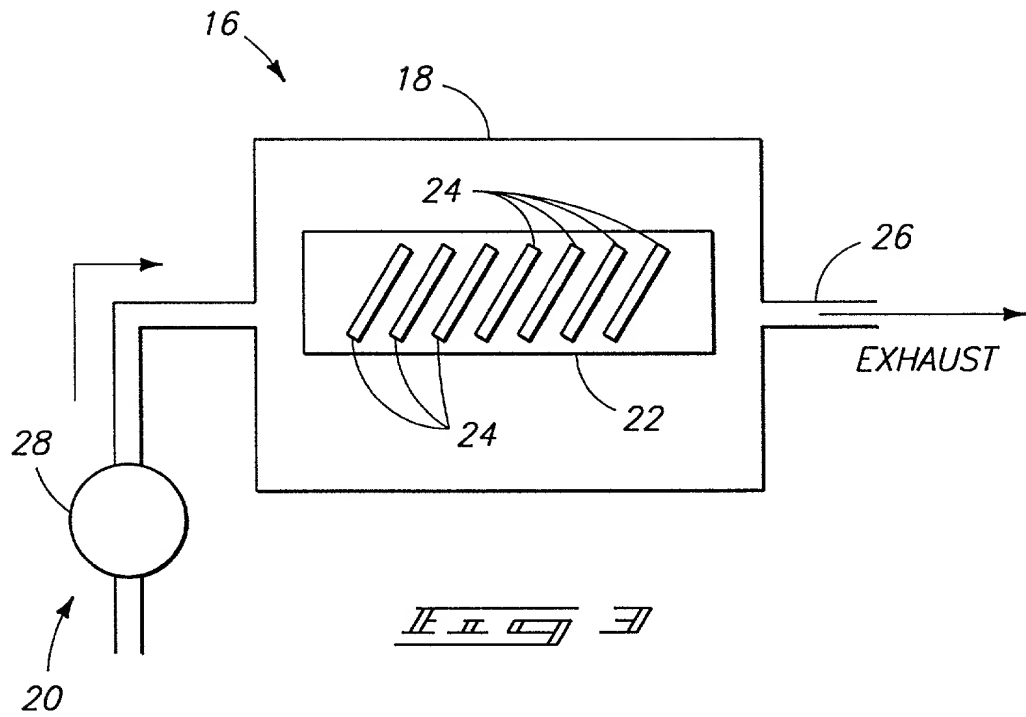


FIG. 2

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1        **DECLARATION OF SOLE INVENTOR FOR PATENT APPLICATION**

2        As the below named inventor, I hereby declare that:

3        My residence, post office address and citizenship are as stated  
4 below next to my name.

5        I believe I am the original, first and sole inventor of the subject  
6 matter which is claimed and for which a patent is sought on the  
7 invention entitled:    **Semiconductor Processing Methods Of Chemical**  
8 **Vapor Depositing SiO<sub>2</sub> On A Substrate**, the specification of which is  
9 attached hereto.

10       I hereby state that I have reviewed and understand the contents  
11 of the above-identified specification, including the claims.

12       I acknowledge the duty to disclose information known to me to  
13 be material to patentability as defined in Title 37, Code of Federal  
14 Regulations §1.56.

15       **PRIOR FOREIGN APPLICATIONS:**

16       I hereby state that no applications for foreign patents or inventor's  
17 certificates have been filed prior to the date of execution of this  
18 declaration.

19       **POWER OF ATTORNEY:**

20       As a named Inventor, I hereby appoint the following attorneys and  
21 agent to prosecute this application and transact all business in the  
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10 (509) 624-4276.

11 I hereby declare that all statements made herein of my own  
12 knowledge are true and that all statements made on information and  
13 belief are believed to be true; and further that these statements were  
14 made with the knowledge that willful false statements and the like so  
15 made are punishable by fine or imprisonment, or both, under  
16 Section 1001 of Title 18 of the United States Code and that such willful  
17 false statement may jeopardize the validity of the application or any  
18 patent issued therefrom.

\* \* \* \* \*

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